Intelligent Battery Management System Analyzing & Optimizing of Multicell Battery Voltage

C.Deepthi

M.Tech(Power Electronics)
Gokaraju Rangaraju Institute of
Engineering & Technology,
Hyderabad, India

P.M.Sarma

Professor (Electrical & Electronics
of Engineering)
Gokaraju Rangaraju Institute of
Engineering & Technology,
Hyderabad, India

M.Chakravarthy

Associate Professor (Electrical &
Electronics of Engineering)
Gokaraju Rangaraju Institute of
Engineering &Technology,
Hyderabad, India

Abstract— **The battery management system (BMS) is a critical component of electric and hybrid electric vehicles. The purpose of the BMS is to guarantee safe and reliable battery operation. To maintain the safety and reliability of the battery, state monitoring and evaluation, charge control, and cell balancing are functionalities that have been implemented in BMS. As an electrochemical product, a battery acts differently under different operational and environmental conditions. The uncertainty of a battery's performance poses a challenge to the implementation of these functions. This paper addresses concerns for current BMSs. State evaluation of a battery, including state of charge, state of health, and state of life, is a critical task for a BMS. Through reviewing the latest Atmel ATA6870 IC technology for the state evaluation of batteries, the future challenges for BMSs are presented and possible solutions are proposed as well.**

Keywords- Battery Management System; Lithium-ion Battery; State of Charge; State of health; State of life.

I. INTRODUCTION

Rechargable multicell batteries have been used in various electrical and electronic systems e.g., renewable energy systems, (hybrid) electric vehicles, commercial electronics, etc. Different types of problems occurred during operation of multicell batteries [1]. A commonly used method to solve the problem of faulty or abnormal cells in a fixed-configuration design is using safety circuits. Safety circuits protect cells from high temperature, overcharge, over discharge, and over current by monitoring the temperature, voltage, and current of each cell. However, lacking an effectively reconfigurable topology, the safety circuits will cut off the whole battery system when any single cell is operating under these abnormal conditions [3].

Moreover, cell state variations are commonly present in multicell batteries. In this case, the fixed-configuration design can only utilize a part of the total battery capacity, which reduces the operating time and lifespan of the battery system [5]. To overcome this deficiency, cell balancing circuits are used. However, most existing balancing circuits use dissipative resistors, resulting in energy loss. The latest products of cell balancing integrated circuits (Atmel ATA6870 DK-10) use electronic converters to transfer charge from cell to cell during operation.

To improve the performance and longvity of standard 12V lead-acid batteries Atmel mega AVR ATmega32HVB is used. This microcontroller is designed for intelligent battery sensor applications, and to determine the state of charge and state of health for standard 12V lead-acid batteries by measuring the battery voltage, current and temperature.

II. BATTERY MONITORING:

In this section, discuss about the performance of indicators in the battery monitoring process. This is followed by the instrumentation in the monitoring process, and the monitoring of multi-cell battery systems.

A. Management of Multi-Cell Batteries:

Due to the production tolerances or operating conditions of batteries, there are small differences in charges between cells that may be magnified with each charge cycle. During charging, weak cells become overstressed, thus cause a further degradation. Weak cells eventually start malfunctioning, and cause a premature failure of the whole battery system. In order to extend the lifetime of (multi-cells) battery systems, dedicated battery management approaches should be developed. For example, weak cells can be compensated by equalizing the charge on each cell in the battery chain [5].

One of the prime functions of the multi-cells BMS is to monitor and control battery cells systemically, in order to protect battery cells and battery systems from abnormal ambient or operating conditions. This function is particularly important in solar power applications because they work in the harsh environment with high temperature and high vibration. For this paper, main aim to design individual cell protection for solar power systems in order to avoid the external fault conditions. This can be done by isolating the battery as well as addressing the fault. For example, the cooling fan should be turned on if the battery overheats, and if the battery is excessively and continuously overheated, the battery should be disconnected [5].
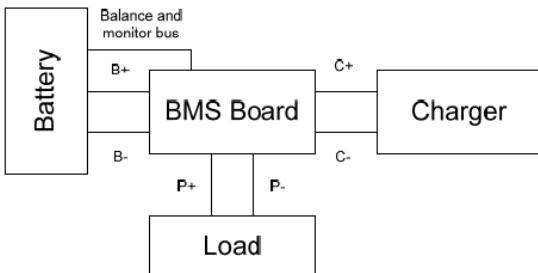
Figure 1.   Typical Battery Management System

III.   HARDWARE IMPLEMENTATION OF BATTERY MANAGEMENT SYSTEM:

Rechargable battery systems have been widely used in different applications. Multi-cell battery management system has been proposed due to manufacturability and safety of battery cells. Thus, battery management system (BMS) is combined with cell packs, sensors, ADC and main processors; in order to monitor and schedule the operation of each battery cells. Fixed-configuration battery systems are widely used in practice, but they usually behave abnormally in extreme conditions such as high temperature, over-charged and over-discharged. In multicell string all cells are not manufactured identically. So the capacities of individual cells will be distributed around an overcharge and also possible for a few cells in a long string to have significantly less capacity than the average [2].

Suppose the string is being discharged at a rate such that the expected cell voltage is 1.8v/cell at the depth of discharge currently in effect and that the discharge cut-off voltage has been sent for 1.75v/cell.

If there are 12 cells in the string and one of the cells has so much less capacity than the rest that is the voltage is zero at this point in the discharge, then the rest of the cells could have an average voltage and the discharge cut-off would not quiet be reached. So clearly, the one cell with discharge current being forced through it with the voltage at zero could quite likely be damaged and the plates will suffer sulphation. If the batteries are over discharged and left in a discharged condition without immediate recharge, battery degradation will occur. However deep discharge batteries are more resistant for repeated deep discharges and revival of battery is simple by extending the period of charging. Deep discharges should be avoided and the batteries should be recharged immediately after every deep discharge.

Over charging occurs when a battery that is fully charged continues to receive a charge. Over charge accelerates gas generation and it may lead to premature dry out of the battery. A small increase in over voltage will increase the corrosion of the positive grid and it will lead to a reduced battery service life. A small amount of over-charging is necessary, and it is good to over-charge the battery once every three to four months. This is called giving the battery an equalization charge. However, if the battery is allowed to over-charge on a frequent basis, it can be damaged quickly. Over charging may not be a problem for larger systems. Hence the cell voltages and battery voltages should be monitored frequently and maintain the recommended float charging voltage.

Battery capacity is decreased at low temperature. For example, at $16.7^{o}C$, capacity is approximately 90% versus 100% at $25^{o}C$. At low temperature, a higher float voltage is required to maintain full charges and, if the charge is not adjusted properly, cells may be undercharged, leading to the problems described for low voltage.

High temperature causes reduction of battery life. For every 9.4°C rise in operating temperature, the life is cut in half. High temperature causes increased float current, which means increased corrosion and, therefore, the loss of life. High temperature also causes gassing, which means loss of water in flooded cells and dry out and thermal runaway in VRLA cells [2].

This study can be divided into the following tasks:

- Developing Battery management system (BMS) which monitors performance and determines the compensation for the degraded performance.

- The BMS system can be implementing by using battery cell network, Data Acquisition boards, power MOSFETs, microcontroller and other peripherals.

- Analyzing and optimizing the BMS performance of battery cell stack voltages and maintain the equal voltage sharing between the multicell batteries.

Safety circuits have been proposed to protect the battery system by switching off the whole system. However, they cannot fully utilize the battery system. Therefore, they are not capable to improve functionality, lifespan and conversion efficiency of battery systems. Recently, some configurable methodologies have been proposed.

Self-calibrated battery management system is proposed for multi-cell battery systems. Battery system operation status is observed through sensors and analyzed through processors. The Atmel ATA6870-DK10 is a demonstration board for the Atmel ATA6870.Which offers an easy way to start evaluation of battery application using the Atmel ATmega32HVB in combination with Atmel ATA6870.

The software which is in AVR studio environment is used to implementation of a 12 cell battery management system. The Atmel ATA6870-DK10 was developed to allow easy evaluation of control software for a microcontroller which controls multiple Atmel ATA6870s. The system was based on a Atmel microcontroller ATmega128 board. This controller board provides 8-bit AVR microcontroller, 16-MHZ system clock, VCC regulator for 3.3V operation.It has the Connectors , Pin header interface X1 and X5 to Atmel ATA6870 Evaluation Board, 6-pin ISP connector for In-System Programming using JTAGICEmkII, Serial connector for PC communication, Supply connector.The evaluation board provides the following items: Atmel ATA6870 QFN 7x7 mm, 12-bit battery cell voltage measurement, Simultaneous battery cells measurement in parallel, Charge balancing capability, Cell temperature measurement, Undervoltage detection, Integrated power supply for MCU, Reliable communication between stacked ICs,12 external N-channel MOSFETs for balancing of battery cells, On-board potentiometers as temperature emulation.
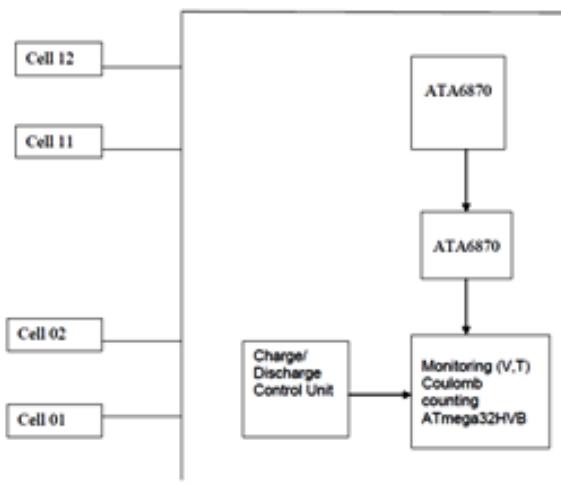
Figure 2.   Atmel ATA6870-DK10 demonstration board

By using USB to serial peripheral port the user program is uploaded into controller board ATmega32 HVB. It sends controlling signal to evaluation board. The ATA6870 IC senses first six cell voltages and evaluates its charging limit input control signal and microcontroller communication interface unit is a bidirectional such that it sense output control signal to another ATA6870 IC. Based on these signals the second IC ATA6870 evaluates remaining six cell voltages.

In this Atmel ATA6870 evaluation board the battery cell voltage and battery cell temperature are monitored in parallel by related 12 bit ADC. The ADC converter converts cell voltages of analog signals to digital signals. These digital signals are feed to the level shifters.

This circuit also provides charge balancing capability for each battery cell by controlling the external discharge N-channel MOSFETS. Level shifters with current sources ensure a reliable communication between stacked IC's. The Atmel ATA6870 evaluation board is controlled by the Atmel ATmega128 controller board via a graphical user interface (GUI), The extension of LABVIEW is added to it to show results of logic control by AVR studio in user interface dialogue box to easy control. By using of Labview each control parameter is formed as icons and output shown in output window in PC.
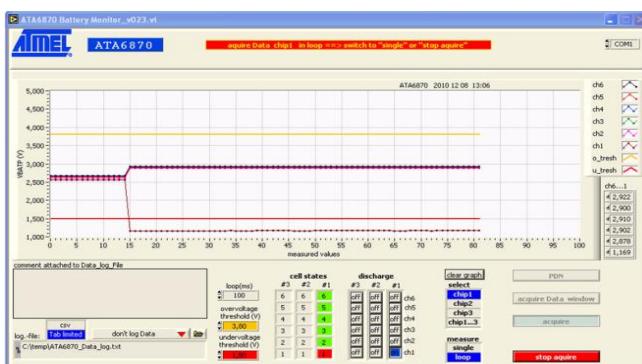
Figure 3.   Standard User Panel with Over- and Undervoltage Detection

IV.   CONCLUSION

In this paper, issues and problems related to multi-cell battery management system design have been discussed. Based on the study, by using Atmel ATA6870 IC measured and sensing the each cell voltages, temperature, and automatically control and monitored the each cell of the battery is done by this microcontroller.

REFERENCES

[1] D. Fisher, A. Lohner, and P. Mauracher, "Battery management: Increase in the reliability of UPS," *ETZ*, vol. 117, pp. 18–22, 1996.

[2] John Chatzakis, Nicholas C.and Stefanos N, "Designing a New Generalized Battery Management System" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 50, NO. 5, OCTOBER 2003.

[3] D. Bell, "A Battery Management System," Master's thesis, School Eng.,Univ. Queensland, St. Lucia, Australia, 2000.

[4] N. Kutkut, D. Divan, and D. Novotny, "Charge equalization for series connected battery strings," *IEEE Trans. Ind. Applicat.*, vol. 31, pp. 562–568, May/June 1995.

[5] C. Chen, K.L. Man, T.O. Ting,T.Krilavičius, Chi-Un Lei, "Design and Realization of a Smart Battery Management System" Proceeding of the International multi conference of Engineers and computer scientists 2012 Vol II, IMECS 2012, March 14-16,2012, Hong Kong.